UNITED
NATIONS

A

General Assembly

Distr.
LIMITED

A/AC.105/C.1/L.213
20 February 1997

ORIGINAL: ENGLISH

COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE
Scientific and Technical Subcommittee
Thirty-fourth session
Vienna, 17-28 February 1997

DRAFT REPORT OF THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE ON THE WORK OF ITS THIRTY-FOURTH SESSION

INTRODUCTION

1. The Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space held its thirty-fourth session at the United Nations Office at Vienna from 17 to __ February 1997 under the chairmanship of D. Rex (Germany).

2. Representatives of the following Member States attended the session: Argentina, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Czech Republic, Ecuador, France, Germany, Greece, Hungary, India, Indonesia, Iran (Islamic Republic of), Iraq, Italy, Japan, Lebanon, Malaysia, Mexico, Morocco, Nicaragua, Nigeria, Pakistan, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, South Africa, Spain, Sudan, Sweden, Syrian Arab Republic, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, United States of America, Uruguay, Venezuela and Viet Nam.

3. Representatives of the following specialized agencies and other organizations in the United Nations system attended the session: Food and Agriculture Organization of the United Nations (FAO), United Nations Education, Scientific and Cultural Organization (UNESCO), World Health Organization (WHO), United Nations Industrial Development Organization (UNIDO) and International Atomic Energy Agency (IAEA).

4. Representatives of the European Space Agency (ESA), Committee on Space Research (COSPAR), International Astronautical Federation (IAF), International Astronomical Union (IAU) and International Society for Photogrammetry and Remote Sensing (ISPRS) also attended the session.

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5. A list of the representatives of Member States, specialized agencies and other international organizations attending the session is contained in document A/AC.105/C.1/INF.26.

6. On 17 February 1997, the Subcommittee adopted the following agenda:

1. Adoption of the agenda.

2. Statement by the Chairman.

3. General exchange of views.

4. United Nations Programme on Space Applications and the coordination of space activities within the United Nations system.

5. Implementation of the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space.

6. Matters relating to remote sensing of the Earth by satellites, including, *inter alia*, applications for developing countries.

7. Use of nuclear power sources in outer space.

8. Space debris.

9. Questions relating to space transportation systems and their implications for future activities in space.

10. Examination of the physical nature and technical attributes of the geostationary orbit; examination of its utilization and applications, including, *inter alia*, in the field of space communications, as well as other questions relating to space communications developments, taking particular account of the needs and interests of developing countries.

11. Matters relating to life sciences, including space medicine.

12. Progress in national and international space activities related to the Earth environment, in particular progress in the international geosphere-biosphere (global change) programme.

13. Matters relating to planetary exploration.

14. Matters relating to astronomy.

15. The theme fixed for special attention at the 1997 session of the Scientific and Technical Subcommittee: "Space systems for direct broadcasting and global information systems for space research".

16. Other matters:

(a) Advisory Committee for the preparations for a special session of the Committee, open to all Member States of the United Nations (UNISPACE III);

(b) Other reports.

17. Report to the Committee on the Peaceful Uses of Outer Space.

A. Meetings and documentation

7. The Subcommittee held __ meetings.

8. A list of the documents which were before the Subcommittee is provided in annex I to the present report.

9. Following the adoption of the agenda, the Chairman made a statement outlining the work of the Subcommittee at its current session. He also reviewed the activities of Member States in the field of space exploration, including important advances that had been achieved as a result of international cooperation during the past year.

10. At the 482nd , 485th, 487th and 488th meetings, the Chairman informed the Subcommittee that requests had been received from the permanent representatives of Bolivia, Cuba, Democratic People's Republic of Korea, Finland, Ireland, Republic of Korea, Slovakia, Thailand and United Arab Emirates, together with the League of Arab States, to attend the session. Following past practice, those delegations were invited to attend the current session of the Subcommittee and to address it as appropriate. That was without prejudice to further requests of that nature, and did not involve any decision of the Subcommittee concerning status, but was a courtesy that the Subcommittee extended to those delegations.

11. General statements were made by the following delegations: Argentina, Austria, Bolivia, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, Ecuador, Germany, Hungary, India, Indonesia, Iran (Islamic Republic of), Italy, Japan, Lebanon, Mexico, Morocco, Nigeria, Pakistan, Republic of Korea, Romania, Russian Federation, Spain, Syrian Arab Republic, Turkey, United Kingdom and United States. General statements were also made by the representatives of COSPAR, IAF and ISPRS.

12. At the 482nd meeting, the Director of the Office for Outer Space Affairs made a statement reviewing the work programme of the Office. At the 485th meeting, the Expert on Space Applications made a statement outlining the activities carried out and planned under the United Nations Programme on Space Applications.

B. Technical presentations

13. In accordance with General Assembly resolution 51/123, paragraph 18 (b) (vii), of 13 December 1996, a symposium on the theme "Space systems for direct broadcasting and global information systems for space research" was organized by COSPAR and IAF to complement discussions within the Subcommittee on the special theme. The first session of the symposium, entitled "Direct broadcasting systems", was held on 17 February and was co-chaired by K. Doetsch, representing IAF, and G. Haerendel, representing COSPAR. The second session of the symposium, entitled "Global information systems for space research", was held on 18 February and was co-chaired by K. Doetsch, representing IAF, and K. Kasturirangan, representing COSPAR.

14. The presentations to the symposium included the following: "Global perspectives of satellite radio and digital audio broadcasting" by K. Kasturirangan of the Indian Space Research Organization; "Multimedia and broadcasting services via satellite" by O. Koudelka of the Technical University of Graz, Austria; "Current status of satellite direct television broadcasting in Russia" by Y. B. Zoubarev of the State Radio Research and Development Institute of the Russian Federation; "Satellite digital television broadcasting systems including the Koreasat DBS system" by J. S. Chae of the Electronic Communications Research Institute of the Republic of Korea; "International networks and satellite data archiving systems in support of Mission to Planet Earth" by R. Schiffer of the National Aeronautics and Space Administration (NASA) of the United States; "Software packages including the use of World Wide Web for research purposes in space science" by M. Machado of the National Commission for Space Activities

of Argentina; "Data and information systems on global climate change (IGBP-DIS) by J. Malingreau of the Joint Research Centre of the European Commission of International Geosphere-Biosphere Programme; and "The role of developing countries in global change and establishment of a global information system" by Zhou C. of the Chinese Academy of Science.

15. In response to General Assembly resolution 51/123, F. Alby (France), J. Bendisch (Germany), S. Toda (Japan), A. Kato (Japan), R. Crowther (United Kingdom), W. Flury of ESA and G. W. Levin of the Inter-Agency Orbital Debris Coordination Committee, made special presentations on the complex issue of space debris and the solutions currently being adopted at the national and international levels.

16. During the course of the session, scientific and technical presentations were made by K. Torkar (Austria) on the Austrian contribution to the cometary probe Rosetta; by S. Sepulveda (Chile) on research on developing medicaments for Chagas' disease through protein crystallization in microgravity conditions; by G. Brachet (France) on integrated global observation strategy; by J. Favier (France) on the scientific and technical aspects of the STS 78 mission; by Y. Matogawa (Japan) on matters relating to planetary exploration; by D. El Hadani (Morocco) on management of water resources in developing countries; by M. Kabbaj (Morocco) on space activities of developing countries: technical possibilities and perspectives; by M. Piso (Romania) on the network of space science and technology capacity building centres in central eastern and south-eastern Europe; by V. I. Lisitsin (Russian Federation) on the Mars 96 mission; by V. Nikolaev (Russian Federation) on collision of nuclear power sources (NPS) with space debris; by A. Pustovalov (Russian Federation) on NPS on board the Mars 96 spacecraft; by B. Wade (United Kingdom) on further thoughts on the revision of the NPS principles; by R. Albrecht of ESA on software packages including the use of World Wide Web for research purposes in space science; and by D. McNally of IAU on adverse environmental impacts on astronomy.

C. Recommendations of the Scientific and Technical Subcommittee

17. After considering the various items before it, the Subcommittee, at its ___ meeting, on __ February 1997, adopted its report to the Committee on the Peaceful Uses of Outer Space containing its views and recommendations as set out in the paragraphs below.

I. UNITED NATIONS PROGRAMME ON SPACE APPLICATIONS AND THE COORDINATION OF SPACE ACTIVITIES WITHIN THE UNITED NATIONS SYSTEM

II. IMPLEMENTATION OF THE RECOMMENDATIONS OF THE SECOND UNITED NATIONS CONFERENCE ON THE EXPLORATION AND PEACEFUL USES OF OUTER SPACE

18. In accordance with General Assembly resolution 51/123, the Subcommittee continued its consideration of the above-mentioned items. In accordance with past practice, the Subcommittee considered the two items jointly.

19. The Subcommittee noted that the General Assembly, in its resolution 51/123, paragraph 24, had once again emphasized the urgency and importance of implementing fully the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82). The Subcommittee took note of paragraph 19 of the same resolution, in which the General Assembly considered that, in the context of the Subcommittee's consideration of that item, it was particularly urgent to implement the following recommendations:

> "(a) All countries should have the opportunity to use the techniques resulting from medical studies in space;
>
> "(b) Databases at the national and regional levels should be strengthened and expanded and an international space information service should be established to function as a centre of coordination;
>
> "(c) The United Nations should support the creation of adequate training centres at the regional level, linked, whenever possible, to institutions implementing space programmes; necessary funding for the development of such centres should be made available through financial institutions;
>
> "(d) The United Nations should organize a fellowship programme through which selected graduates or postgraduates from developing countries should get in-depth, long-term exposure to space technology or applications; it is also desirable to encourage the availability of opportunities for such exposure on other bilateral or multilateral bases outside the United Nations system."

20. In response to the recommendations of the Working Group of the Whole to Evaluate the Implementation of the Recommendations of UNISPACE 82, contained in its report on the work of its tenth session, held in 1996 (A/AC.105/637 and Corr.1, annex II, paras. 7-44), which were endorsed by the General Assembly in resolution 51/123, paragraph 20, the Subcommittee had before it the following documents: a report on international cooperation in the peaceful uses of outer space: activities of Member States (A/AC.105/661 and Add.1 and 2), containing information submitted by Member States in response to paragraph 9 of the report of the Working Group of the Whole; a note by the Secretariat containing a summary of a study on basic space science in developing countries (A/AC.105/664), prepared pursuant to paragraph 4 (c) of the report of the Working Group; and a note by the Secretariat to which was annexed a study on the use of new technologies in satellite communications and information networks (A/AC.105/665), prepared pursuant to paragraph 11 (b) of the report of the Working Group of the Whole. In addition, the Subcommittee had before it annual reports that included information submitted by the following international organizations in response to paragraph 10 of the report of the Working Group of the Whole: European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) (A/AC.105/670), ESA (A/AC.105/653), European Telecommunications Satellite Organization (EUTELSAT) (A/AC.105/652) and International Telecommunications Satellite Organization (INTELSAT) (A/AC.105/651).

21. In accordance with General Assembly resolution 51/123, paragraph 21, the Subcommittee reconvened the Working Group of the Whole with a view to improving the execution of activities relating to international

cooperation, particularly those included in the United Nations Programme on Space Applications, and to proposing concrete steps to increase such cooperation as well as to make it more efficient. The Working Group of the Whole was chaired by Muhammed Nasim Shah (Pakistan); it held ___ meetings between 19 and __ February 1997 and adopted its report on __ February 1997.

22. Having considered the report of the Working Group of the Whole, the Subcommittee decided at its __th meeting, on __ February 1997, to adopt that report, as contained in annex II to the present report, on the understanding that the recommendations contained therein would be carried out in accordance with paragraph 9 of General Assembly resolution 37/90 of 10 December 1982. The Subcommittee recommended that the Working Group of the Whole should be reconvened in 1998 to continue its work.

A. United Nations Programme on Space Applications

23. Regarding the expanded United Nations Programme on Space Applications, the Subcommittee had before it the report of the United Nations Expert on Space Applications (A/AC.105/660 and Add.1). The report was supplemented by a statement by the Expert. The Subcommittee noted that the United Nations Programme on Space Applications for 1996 had been carried out satisfactorily and commended the work accomplished by the Expert in that regard.

24. The Subcommittee noted with appreciation that, since its previous session, additional contributions had been offered by various Member States and organizations and that they had been acknowledged in the report of the Expert (A/AC.105/660 and Add.1, paras. 34-35).

25. The Subcommittee continued to express its concern over the still limited financial resources available for carrying out the Programme and appealed to Member States to support the Programme through voluntary contributions. The Subcommittee felt that the limited resources of the United Nations should be focused on the activities with the highest priority and noted that the United Nations Programme on Space Applications was the priority activity of the Office for Outer Space Affairs.

1. 1996-1997

United Nations conferences, training courses, workshops, expert meetings and symposia

26. With regard to the activities of the Programme carried out in 1996 and early in 1997, the Subcommittee expressed its appreciation to the following:

(a) The Government of the United States for co-sponsoring the United Nations/United States of America International Conference on Spin-off Benefits of Space Technology: Challenges and Opportunities, held at Colorado Springs, Colorado, from 9 to 12 April 1996;

(b) The Government of the Philippines, as well as ESA, for co-sponsoring the United Nations/European Space Agency Workshop on Microwave Remote Sensing Applications, hosted by the National Mapping and Resource Information Authority of the Philippines and held at Manila from 22 to 26 April 1996;

(c) The Government of Sweden, represented by the Swedish International Development Agency, for co-sponsoring the Sixth United Nations International Training Course on Remote Sensing Education for Educators, hosted by the Department of Physical Geography of Stockholm University and the Swedish Space Corporation and held at Stockholm and Kiruna from 6 May to 15 June 1996;

(d) The Government of Chile, as well as ESA, for co-sponsoring the United Nations/Chile/European Space Agency Regional Workshop on Space Technology to Prevent and Mitigate the Effects of Disasters, hosted by the Ministerio de Relaciones Exteriores, the Oficina Nacional de Emergencia del Ministerio del Interior, the Comité de Asuntos Espaciales de Chile and the Fuerza Aérea de Chile and held at Santiago from 1 to 5 July 1996;

(e) The Government of Austria, as well as the province of Styria, the city of Graz, the European Commission and ESA, for co-sponsoring the United Nations/European Space Agency/European Commission Symposium on Space Technology Applications for the Benefit of Developing Countries, held at Graz from 9 to 12 September 1996;

(f) The Government of Germany, as well as ESA, for co-sponsoring the Sixth United Nations/European Space Agency Workshop on Basic Space Science, hosted by the German Space Agency (DARA) at the Max Planck Institute for Radio Astronomy and held at Bonn from 9 to 13 September 1996;

(g) The Government of Spain, as well as ESA, for co-sponsoring the United Nations/Instituto Nacional de Técnica Aeroespacial/European Space Agency International Conference on Small Satellites: Missions and Technology, hosted by the Instituto Nacional de Técnica Aeroespacial and held at Madrid from 9 to 13 September 1996;

(h) The Government of China, IAF and ESA, for co-sponsoring the United Nations/International Astronautical Federation Workshop on Education and Awareness: Space Technology and Applications in the Developing World, held at Beijing from 3 to 6 October 1996;

(i) The Government of South Africa for co-sponsoring the Second United Nations Regional Conference on Space Technology for Sustainable Development in Africa, held at Pretoria from 4 to 8 November 1996;

(j) The Government of India, as well as ESA, for co-sponsoring the United Nations/European Space Agency Workshop on Satellite Communications, hosted by the Government of India in cooperation with the Centre for Space Science and Technology Education in Asia and the Pacific and held at Ahmedabad from 20 to 24 January 1997;

(k) The Government of Austria for sponsoring, in cooperation with the United Nations, the United Nations Seminar on Space Futures and Human Security, hosted by the Austrian Federal Ministry of Foreign Affairs and the province of Tyrol and held at Alpbach from 27 to 30 January 1997.

27. The Subcommittee took note of the status of United Nations workshops, training courses, symposia and conferences planned for 1997, including the following described in the report of the Expert on Space Applications (A/AC.105/660 and Add.1, annex V):

(a) Second United Nations/United States of America International Conference on Spin-off Benefits of Space Technology: Challenges and Opportunities, being organized in cooperation with the Government of the United States, to be held at Colorado Springs, Colorado, in October 1997;

(b) Seventh United Nations/International Training Course on Remote Sensing Education for Educators, being organized in cooperation with the Government of Sweden, to be held at Stockholm and Kiruna from 5 May to 13 June 1997;

(c) Seventh United Nations/European Space Agency Workshop on Basic Space Science, being organized in cooperation with the Government of Honduras, to be held at Tegucigalpa from 16 to 20 June 1997;

(d) United Nations/European Space Agency workshop on the cooperative information network linking scientists, educators, professionals and decision makers in Africa (COPINE), to be held in Africa in the second or third quarter of 1997;

(e) United Nations/European Space Agency Symposium on Space Industry Cooperation with the Developing World, being organized with the Government of Austria, the province of Styria, the city of Graz and ESA, to be held at Graz from 8 to 11 September 1997;

(f) United Nations/Committee on Space Research Workshop on Data Analysis Techniques, being organized in cooperation with the Government of Brazil and the Centre for Space Science and Technology Education in Latin America and the Caribbean, to be held in Brazil in September or October 1997;

(g) Fourth United Nations/European Space Agency Training Course on Applications of the European Remote Sensing Satellite Data for English-speaking African countries, to be held at Frascati, Italy, in October 1997;

(h) United Nations International Workshop on Satellite Communications Technology for Capacity-building, being organized in cooperation with the Government of Israel, to be held at Haifa from 21 to 25 September 1997;

(i) United Nations/International Astronautical Federation Workshop on Space Technology as a Cost-Effective Tool to Improve Infrastructure in Developing Countries, being co-sponsored by ESA and the European Commission and organized in cooperation with the Government of Italy, to be held at Torino from 2 to 5 October 1997;

(j) Second United Nations Seminar on Space Futures and Human Security, to be held in the province of Tyrol in December 1997 and/or January 1998.

Long-term fellowships for in-depth training

28. The Subcommittee expressed appreciation to ESA for having offered five training fellowships in various areas relating to space activities for the period 1996-1997. The status of the fellowships for the period 1996-1997 and the countries whose candidates had received fellowships were indicated in the report of the Expert (A/AC.105/660 and Add.1, annex II).

29. The Subcommittee noted that it was important to increase the opportunities for in-depth education in all areas of space science, technology and applications projects through long-term fellowships.

Technical advisory services

30. The Subcommittee took note of the technical advisory services being provided under the United Nations Programme on Space Applications in support of projects on regional space applications, as indicated in the report of the Expert (A/AC.105/660 and Add.1, paras. 16-28):

(a) Assistance to the Government of Uruguay in its follow-up, as *pro tempore* secretariat, of the recommendations of the Third Space Conference of the Americas;

(b) Assistance to the Government of the Republic of Korea in the growth and operation of the Asia-Pacific Satellite Communications Council;

(c) Collaboration with several African countries on the implementation of the COPINE project in order to address one of the recommendations of the United Nations Regional Conference on Space Technology for Sustainable Development in Africa, held at Dakar from 25 to 29 October 1993, regarding the urgent need to establish an efficient communications network among African and European professionals and scientists at the national, continental and intercontinental levels;

(d) Collaboration with ESA and the Department for Development Support and Management Services of the Secretariat in follow-up activities related to the recommendations of the training courses on applications of the European Remote Sensing Satellite data to natural resources, renewable energy and the environment held at Frascati, Italy, in 1993, 1994 and 1995;

(e) Collaboration with ESA on follow-up activities relating to the series of workshops on basic space science;

(f) Elaboration of an inter-agency project proposal on a satellite-based disaster warning broadcasting system for small island developing States.

Promotion of greater cooperation in space science and technology

31. The Subcommittee noted that the United Nations was collaborating with international professional bodies in the space community to promote the exchange of experiences on space activities. The United Nations Programme on Space Applications had co-sponsored the United Nations/IAF/ESA Workshop on Education and Awareness: Space Technology and Applications in the Developing World, held at Beijing in October 1996 in conjunction with the 47th IAF Congress. Participants at the Workshop also attended the Congress. The Subcommittee noted that in 1996 the Programme had co-sponsored the participation of scientists from developing countries in the Thirty-First Scientific Assembly of COSPAR, held at Birmingham, United Kingdom, from 14 to 21 July 1996.

32. The Subcommittee noted that in 1997, the Programme would co-sponsor the participation of scientists from developing countries in the United Nations/IAF Workshop to be co-sponsored by ESA and EC on Space Technology as a Cost-Effective Tool to Improve Infrastructures in Developing Countries, to be held at Torino, Italy, from 2 to 5 October 1997 in conjunction with the 48th IAF Congress, and that participants at the Workshop would also attend the IAF Congress to be held from 6 to 10 October 1997.

2. 1998

United Nations conferences, training courses, workshops and symposia

33. The Subcommittee recommended the approval of the following programme of conferences, training courses, workshops and symposia proposed for 1998 which, with the exception of item (a), would be used as preparatory meetings for the UNISPACE III Conference:

(a) Eighth United Nations International Training Course on Remote Sensing Education for Educators;

(b) United Nations/European Space Agency Regional Meeting on Space Technology and Applications for Development (with emphasis on microwave remote sensing applications and including preparations for the UNISPACE III Conference), Malaysia, Asia and the Pacific;

(c) United Nations Regional Conference for Decision Makers on Space Technology Development (including preparations for the UNISPACE III Conference), Africa;

(d) United Nations Regional Meeting on Space Technology and Applications for Development (with emphasis on information technology and including preparations for the UNISPACE III Conference), Latin America and the Caribbean;

(e) United Nations/Austria Symposium on Economic Benefits of Applying Space Systems in Support of Resources Planning, Education and Communication Infrastructure (including preparations for the UNISPACE III Conference), Graz, Austria;

(f) The Third United Nations Regional Conference on Spin-off Benefits of Space Technology (Asia/Caribbean);

(g) United Nations/IAF Workshop on Expanding the User Community of Space Technology in Developing Countries, Melbourne, Australia;

(h) United Nations Third Seminar on Space Futures and Human Security, province of Tyrol, Austria.

B. International space information service

34. The Subcommittee noted with satisfaction that the Office for Outer Space Affairs had continued to develop a World Wide Web home page, including both information within the United Nations system and access to external databases.

35. The Subcommittee noted with satisfaction the publication of documents entitled *Seminars of the United Nations Programme on Space Applications: Selected Papers on Space Science Education, Remote Sensing and Small Satellites* (A/AC.105/650) and *Education, Training, Research and Fellowship Opportunities in Space Science and Technology and Its Applications: A Directory* (A/AC.105/671).

C. Reports

36. The Subcommittee took note with appreciation of the reports submitted to it by Member States and international organizations in response to the recommendations of the Working Group of the Whole in its report on the work of its ninth session. It also noted with satisfaction that the Secretariat had prepared studies on basic space science in developing countries (A/AC.105/664) and the use of new technologies in satellite communications and information networks (A/AC.105/665).

D. Coordination of space activities within the United Nations system and inter-agency cooperation

37. The Subcommittee noted that the General Assembly, in its resolution 51/123, had invited all Governments within the organizations of the United Nations system and other intergovernmental organizations working in the field of outer space or on space-related matters to take effective action for the implementation of the recommendations of UNISPACE 82.

38. The Subcommittee continued to stress the necessity of ensuring continuous and effective consultations and coordination in the field of outer space activities among organizations within the United Nations system and the avoidance of duplication of activities. The Subcommittee noted that the sessions of the Inter-Agency Meeting on Outer Space Activities are to be convened at the United Nations Office at Vienna, and hosted by the Office for Outer Space Affairs, prior to the sessions of the Committee each year, without prejudice to any invitation by an interested agency to host a session at its headquarters. The Subcommittee noted with satisfaction that the Inter-Agency Meeting on Outer Space Activities was scheduled to be held at the United Nations Office at Vienna, from 28 to 30 May 1997.

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Distr.
LIMITED

A/AC.105/C.1/L.213/Add.1
24 February 1997

ORIGINAL: ENGLISH

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DRAFT REPORT OF THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE ON THE WORK OF ITS THIRTY-FOURTH SESSION

VI. QUESTIONS RELATING TO SPACE TRANSPORTATION SYSTEMS AND THEIR IMPLICATIONS FOR FUTURE ACTIVITIES IN SPACE

1. In accordance with General Assembly resolution 51/123, the Subcommittee continued its consideration of the item relating to space transportation systems.

2. In the course of the discussion, delegations reviewed national and international cooperative programmes in space transportation systems, including expendable launchers, reusable space shuttles and space stations. In particular, the Committee noted that China was continuing the use and development of its Long March series of launch vehicles; that India was continuing development of the Geostationary Satellite Launch Vehicle and had succeeded in the developmental launchings of the Polar Satellite Launch Vehicle; that Japan had started to upgrade its H-II launch vehicle, had successfully launched the J-I and M-V launch vehicles and was continuing its development of the H-IIA launch vehicle; that the Russian Federation had launched space objects of various types using expendable launchers of the Soyuz, Cosmos, Proton and other series and had sent a number of national and international crews to the Mir space station; that Ukraine, in cooperation with the Russian Federation, was continuing to produce and successfully use the Tsyklon and Zenit rocket launchers, as well as offering them for use in international cooperative activities; that Spain was developing the indigenous launcher Capricornio, that the United Kingdom was cooperating with ESA in its Future European Space Transportation Investigation Programme (FESTIP); that the United States was continuing its programme of expendable launches and flights of the reusable Space Shuttle, many of the flights involving significant international participation, particularly during the link-ups of the Space Shuttle Atlantis with the Mir station; that Canada, Japan, the Russian Federation and the United States, together with ESA, were continuing preparations for the International Space Station programme; and that ESA was continuing its development of the Ariane series of launch vehicles.

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3. The Subcommittee took note of developments in the United States commercial launch industry, including the Atlas, Delta and Pegasus expendable vehicles and the Reusable Launch Vehicle (RLV) three-pronged programme that included the X-33 sub-orbital vehicle. In that connection, the Subcommittee noted that the X-33 test vehicle was the most advanced part of the RLV programme, aimed at developing the kinds of technologies required by industry to build a new launch vehicle that would provide affordable and reliable access to space. The Subcommittee took note of the Automatic Landing Flight Experiment (ALFLEX) and study of the HOPE-X experimental unmanned winged vehicle of Japan.

4. The Subcommittee took note of developments in the Russian Federation, including the improved Proton-M launcher, the ecologically clean Rus and Angara launchers. The Subcommittee also took note of the introduction into the space transportation system of the Russian Federation of the Start-1, Start and Rokot launchers that were based on converted ballistic missiles. The Subcommittee further noted that progress was being made in the plans for the construction of a new cosmodrome called Svobodny in the eastern part of the Russian Federation were progressing, as well as in the plans for the modernization of the Baikonur cosmodrome in Kazakstan in connection with its increased use for commercial launchings by international enterprises.

5. The Subcommittee stressed the importance of international cooperation in space transportation in order to provide all countries with access to the benefits of space science and technology.

6. The Subcommittee recommended that consideration of the item be continued at its next session.

VII. EXAMINATION OF THE PHYSICAL NATURE AND TECHNICAL ATTRIBUTES OF THE GEOSTATIONARY ORBIT; EXAMINATION OF ITS UTILIZATION AND APPLICATIONS, INCLUDING, *INTER ALIA*, IN THE FIELD OF SPACE COMMUNICATIONS, AS WELL AS OTHER QUESTIONS RELATING TO SPACE COMMUNICATIONS DEVELOPMENTS, TAKING PARTICULAR ACCOUNT OF THE NEEDS AND INTERESTS OF DEVELOPING COUNTRIES

7. In accordance with General Assembly resolution 51/123, the Subcommittee continued its consideration of the item relating to the geostationary orbit and space communications.

8. In the course of the discussion, delegations reviewed national and international cooperative programmes in satellite communications, including progress in communications satellite technology that would make satellite communications more accessible and less expensive and would increase the communications capacity of the geostationary orbit and the electromagnetic spectrum.

9. The Subcommittee took note of the growing use of communications satellite systems for telecommunications, television broadcasting, data networks, environmental data relay, mobile communications, disaster warning and relief, telemedicine and other communications functions.

10. Some delegations expressed the view that the geostationary orbit was a limited natural resource and that saturation should be avoided in order to ensure that all countries had non-discriminatory access to the orbit. Those delegations felt that a special *sui generis* legal regime was required to ensure equitable access by all States, particularly developing countries. They felt that the role of the International Telecommunication Union

(ITU), which concerned the technical aspects, and of the Committee on the Peaceful Uses of Outer Space with respect to the geostationary orbit were complementary. Other delegations expressed the view that questions relating to the geostationary orbit were being addressed effectively by ITU. Some delegations expressed the view that, in considering the question of equitable access, account should be taken in particular of the geographic situation of the equatorial countries.

11. The view was expressed that on the basis of considerations in the Scientific and Technical Subcommittee, the Legal Subcommittee could draft an appeal to the World Radiocommunication Conference to be held later in 1997 with the aim of stressing the principle of guaranteeing equitable access to the geostationary orbit, as well as a possible solution to the congestion of the geostationary orbit by "paper" satellites, and that that appeal could be regarded as a finalization of deliberations on the matter in the Legal Subcommittee.

12. Some delegations noted that the use of the geostationary orbit, like other orbits, was affected by the problem of space debris and that efforts were needed to minimize the generation of debris in the orbit and to move satellites shortly before the end of their useful lives into disposal orbits beyond the geostationary orbit.

13. The Scientific and Technical Subcommittee recommended that consideration of the item relating to the geostationary orbit and space communications be continued at its next session.

VIII. PROGRESS IN NATIONAL AND INTERNATIONAL SPACE ACTIVITIES RELATED TO THE EARTH ENVIRONMENT, IN PARTICULAR PROGRESS IN THE INTERNATIONAL GEOSPHERE-BIOSPHERE (GLOBAL CHANGE) PROGRAMME

14. In accordance with General Assembly resolution 51/123, the Subcommittee continued its consideration of the item concerning progress in national and international space activities related to the Earth environment, in particular progress in the International Geosphere-Biosphere (Global Change) Programme.

15. The Subcommittee noted the progress being made through international cooperation in the International Geosphere-Biosphere (Global Change) Programme, with the participation of many countries. It also noted that such a joint international effort was of fundamental importance for examining the future habitability of the planet and for managing the common natural resources of Earth. The Subcommittee took particular note of the need to involve as many countries as possible in the scientific activities of the Programme, both in developed and in developing countries.

16. The Subcommittee noted that a special two-day symposium, entitled "Transformation and Analysis of Space Obtained Geophysical Data for Global Change Studies", would be organized during the Thirty-Second Scientific Assembly of COSPAR, to be held at Nagoya, Japan, in 1998. The aim of that symposium would be to assist developing countries in realizing the new possibilities for global change studies that were currently available through the use of satellite remote sensing data.

17. The Subcommittee took note of the important contributions of satellite remote sensing to environmental monitoring, to planning sustainable development, to water-resource development, to monitoring crop conditions and to predicting and assessing drought. The Subcommittee noted that the Center for Climatic Studies and Forecasting of Brazil was fully operational and that its weather and climate reports were available free of charge.

18. The Subcommittee noted the important contribution of meteorological and atmospheric research satellites to studying global climate change, the greenhouse effect, the degradation of the ozone layer and other oceanic and global environmental processes. The previously launched Topex/Poseidon oceanographic satellite, the National Oceanic and Atmospheric Administration (NOAA) series, the geostationary operational environmental satellite (GOES) series, Total Ozone Mapping System, RADARSAT, Earth Resources Satellite (ERS) 1 and 2, the Japanese Earth Resources Satellite (JERS-1), the Indian Research Satellite series, the Sich 1 satellite and the recently launched ADEOS 1 satellite, were important tools for that purpose, as would be the planned Phase II Mission to Planet Earth enterprise under the new NASA Millennium Programme, the Jason 1 Programme, TRMM, Envisat, Meteor, Meteosat, NOAA-K, GOES-K and other similar spacecraft. The Subcommittee noted the need for further space research relating to climate change, energy exchange between the atmosphere and land and ocean surfaces, weather patterns, vegetation distribution and other environmental factors.

19. The Subcommittee noted with satisfaction that during the symposium organized by COSPAR and IAF and held during its current session, several presentations were devoted to the collection, processing and archiving of data within the framework of the Mission to Planet Earth and the International Geosphere-Biosphere (Global Change) Programme, as described in section XI of the present report.

20. The Subcommittee noted the importance of international cooperation in the various existing and planned satellite systems for environmental monitoring. It recommended that other States should consider participating in such cooperative activities.

21. The Subcommittee recommended that consideration of the item be continued at its next session.

IX. MATTERS RELATING TO LIFE SCIENCES, INCLUDING SPACE MEDICINE

22. In accordance with General Assembly resolution 51/123, the Subcommittee continued its consideration of the item relating to life sciences.

23. The Subcommittee recalled that the General Assembly, in its resolution 51/123, had considered it particularly important that all countries should have the opportunity to use the techniques resulting from medical studies in space.

24. The Subcommittee noted that studies of human and animal physiology under the microgravity conditions of space flight had led to important advances in medical knowledge in such areas as blood circulation, hypertension, osteoporosis, cardiovascular physiology, sensory perception, immunology and the effects of cosmic radiation. It noted that important new information in those fields had been obtained through experiments on the Mir space station, particularly during the flights of ESA, French, German and United States astronauts aboard that space station. Important data were gathered during several United States Space Shuttle missions, including flights involving Canadian and French astronauts. Important data were also gathered from biological experiments on the BION 11 satellite, launched by the Russian Federation with the participation of experts from France, Ukraine and the United States and from experiments on sounding rockets such as TEXUS.

25. The Subcommittee took note of a bilateral German-Russian cooperation project entitled MIR '97, which would take advantage of this long-duration manned mission for experiments focusing on human physiology, materials sciences and technology. It also noted the French-German cooperation in the development of a diagnostic facility for cardiovascular research in space, CARDIOLAB, to be used on the International Space Station, and the development by the space agencies of Bulgaria, Germany and the Russian Federation of a new generation of medical

measuring equipment, the Bulgarian Neurolab-B and the automatic bio-technological system SVET, as well as the Hungarian thermoluminescent dosimeter (Pille).

26. The Subcommittee noted that applications of space technologies were demonstrating growing promise in medicine and public health on Earth as reported by France and the Russian Federation. In that connection, the Subcommittee noted that specialists from Argentina, Brazil, Chile, Costa Rica, Uruguay and the United States were preparing a biotechnology experiment consisting of growing two types of proteins under microgravity conditions. The proteins could be used to develop new drugs for the control of infectious diseases such as Chagas' disease. The Subcommittee also noted that products of space biotechnology, such as pharmaceutical and medical instruments, could contribute to improved health care. The Subcommittee noted the importance of space technology for those purposes and encouraged further research and exchange of information on those applications.

27. The Subcommittee noted that space studies in life sciences and medicine had important potential benefits for all countries and that efforts should be made to promote international cooperation to enable all countries to benefit from those advances. The Subcommittee heard a special presentation by the delegation of Chile on the research on developing medicaments for Chagas' disease through protein crystallization in microgravity conditions, as mentioned in paragraph __ above.

28. The Subcommittee recommended that consideration of the item be continued at its next session.

X. MATTERS RELATING TO PLANETARY EXPLORATION AND MATTERS RELATING TO ASTRONOMY

29. In accordance with General Assembly resolution 51/123, the Subcommittee continued its consideration of the item on planetary exploration and the item on astronomy.

30. The Subcommittee noted that several planetary exploration missions were currently under way. The Galileo spacecraft had successfully manoeuvred into orbit around Jupiter and started a complex investigation of its natural satellite system; the Ulysses spacecraft had continued its investigations of the solar polar regions during its extended mission. The Subcommittee noted the launchings by the United States of the Mars Global Surveyor and Pathfinder for global observation of Mars and the Near-Earth Asteroid Rendezvous (NEAR) mission for the study and observation of asteroids. It also noted missions planned for future launch, including the Lunar Prospector for lunar exploration; Cassini/Huygens, for investigation of Saturn and its moons; and the Stardust and Rosetta missions to asteroids and comets. The Subcommittee noted the high degree of international cooperation in all of those investigations and stressed the need to further enhance international cooperation in planetary exploration to enable all countries to benefit from and participate in those activities.

31. The Subcommittee noted that a research team of NASA and other scientists had found evidence that primitive forms of microscopic life might have existed on Mars 3 billion years ago. The research was based on sophisticated examination of an ancient Martian meteorite (ALH84001) that had landed on Earth some 13,000 years ago. The Subcommittee also noted that NASA was investigating the feasibility of bringing scientifically significant samples from Mars.

32. The Subcommittee noted that the use of spacecraft for making astronomical observations from above the atmosphere had greatly advanced knowledge of the universe by allowing observations in all regions of the electromagnetic spectrum. It noted that with the upgraded and repaired Hubble Space Telescope, Rosat, Compton Gamma Ray Observatory, Extreme Ultraviolet Explorer, Astro-D, Freja, Koronas I, Polar and Wind satellites, the

SAX astronomy satellite, the Magion 4 and 5 sub-satellites, and the Orfeus 2 ultraviolet spectrometer, and with data from the recent ASTRO-SPAS sub-satellites, Interball, Infrared Space Observatory, Solar and Heliospheric Observatory and the radioastronomy satellite Haruka, as well as the Spartan series of sub-satellites, astronomers had powerful tools for their investigations of the universe. The planned launches of the Radioastron satellite, Spektr-Roentgen-Gamma observatory, Advanced X-ray Astrophysics Facility, Space Infrared Telescope Facility, Spektr-UV, International Gamma Ray Astronomy Laboratory (INTEGRAL), Very Long Base Interferometry Space Observatory, X-ray Multi-Mirror Mission (XMM), Gamma 1 and 400, Ikon, Relikt 3 and many others would open up further realms of the universe to detailed observation. The Subcommittee noted with satisfaction that all of those projects were open to broad international cooperation.

33. The Subcommittee took note of the resolution adopted by the COSPAR Council at its thirty-first session in July 1996, in which the Council stated that it was vitally important to preserve an adequate spectrum range for astronomical radio science and atmospheric environmental science and its application. The Subcommittee heard presentations by IAU on adverse environmental impacts on astronomy and by the delegation of Japan on planetary exploration, as described in paragraph __ of the present report.

34. The Subcommittee recommended that consideration of the items be continued at its next session.

XI. THE THEME FIXED FOR SPECIAL ATTENTION AT THE 1997 SESSION: SPACE SYSTEMS FOR DIRECT BROADCASTING AND GLOBAL INFORMATION SYSTEMS FOR SPACE RESEARCH

35. In accordance with General Assembly resolution 51/123, the Subcommittee paid special attention to the theme "Space systems for direct broadcasting and global information systems for space research". The Subcommittee noted with satisfaction that, at its invitation, COSPAR and IAF had organized on 17 and 18 February 1997 a symposium on the theme, as described in paragraphs __ and __ of the present report.

36. The Subcommittee also heard special presentations on the special theme by the delegation of Spain and by ESA, as described in paragraph __ of the present report.

37. The Subcommittee took note of the fact that space systems for direct broadcasting had already matured and developed into a valuable tool for global education and information exchange. They were capable of providing multimedia services such as integrated video, voice and computer applications including Internet connectivity. Such systems significantly contributed to the globalization of the world economy and to deregulation and competition in the field of commercial communications. At the same time, the Subcommittee noted that there were still large areas in the world lacking basic communications services. The Subcommittee further noted the importance of satellite radio and digital audio broadcasting systems, which could provide inexpensive means of communication and education to remote areas.

38. The Subcommittee noted the role of developing countries in the Global Change Programme. It also noted that the establishment of a global information system for space research was important to promoting their participation. While developing countries were experiencing significant environmental change as a result of the demands from a growing population and extensive economic development strategies, they were increasingly becoming aware of the serious environmental problems they were facing. The Subcommittee also noted that space systems were essential to the collection and distribution of all kinds of research data and that future global information systems should also include national airborne systems and a national ground observation network. Regarding data processing and archiving, the Subcommittee noted that to fully exploit the potential of already

acquired and future research data, more international cooperation was needed for their proper archiving, to ensure global free access to databases, to develop mechanisms for improving access to meta-data, and to agree on formats and software packages for data conversion that were necessary for scientific research.

39. The Subcommittee also took note of information on the Spanish national geostationary communications system, HISPASAT, and the new policy of Brazil regarding the definition of direct broadcasting and direct-to-home systems dealt with within the frequency coordination efforts of ITU.

40. On the basis of the results of its deliberations on this special theme, the Subcommittee recommended that cooperation efforts should include the dissemination of information on the potential of direct broadcasting and the promotion of ways of accessing global information systems.

XII. OTHER MATTERS

A. Advisory Committee preparations for the Special Session of the Committee on the Peaceful Uses of Outer Space (UNISPACE III Conference)

[Paragraphs to be added]

B. Other reports

41. The Subcommittee welcomed the annual reports of EUMETSAT (A/AC.105/670), EUTELSAT (A/AC.105/652), INTELSAT (A/AC.105/651) and ESA (A/AC.105/653). The Subcommittee requested those organizations to continue to report on their work.

42. The Subcommittee expressed its appreciation to COSPAR for its report on the progress in space research and to IAF for its report on space technology and applications, the two reports being issued jointly under the title *Highlights in Space: Progress in Space Science, Technology and Applications, International Cooperation and Space Law, 1996* (A/AC.105/654).

43. The Subcommittee noted with appreciation the participation in its session of representatives from United Nations bodies, specialized agencies and permanent observers and found their statements and reports helpful in enabling the Subcommittee to fulfil its role as focal point for international cooperation in space.

C. Review of the future role and work of the Scientific and Technical Subcommittee

44. The Subcommittee recommended that the agenda for its thirty-fifth session should include the following priority items:

(a) Consideration of the United Nations Programme on Space Applications and the coordination of space activities within the United Nations system;

(b) Implementation of the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space; and preparations for the Special Session of the Committee on the Peaceful Uses of Outer Space (UNISPACE III Conference) by the Advisory Committee;

(c) Matters relating to remote sensing of the Earth by satellites including, *inter alia*, applications for developing countries;

(d) Use of nuclear power sources in outer space;

(e) Space debris.

45. The Subcommittee recommended that the agenda for its thirty-fifth session should also include the following items:

(a) Questions relating to space transportation systems and their implications for future activities in space;

(b) Examination of the physical nature and technical attributes of the geostationary orbit and of its utilization and applications, including, *inter alia*, in the field of space communications, as well as other questions relating to space communications developments, taking particular account of the needs and interests of developing countries;

(c) Matters relating to life sciences, including space medicine;

(d) Progress in national and international space activities related to the Earth's environment, in particular progress in the International Geosphere-Biosphere (Global Change) Programme;

(e) Matters relating to planetary exploration;

(f) Matters relating to astronomy;

(g) Consideration of the theme fixed for special attention at the thirty-fifth session of the Scientific and Technical Subcommittee: "___".

46. The Subcommittee recommended that, regarding agenda item (g) in paragraph ___ above, COSPAR and IAF, in liaison with Member States, should be invited to arrange a symposium, with as wide a participation as possible, to be held during the first week of the thirty-fifth session, to complement discussions by the Subcommittee on the special theme.

47. With regard to the dates for the thirty-fifth session, the Subcommittee recommended that it be scheduled from __ to __ February 1998.

D. Tribute

48. The Chairman, on behalf of the Subcommittee, expressed his condolences to the delegation of China on the passing away of that country's paramount leader, Deng Xiaoping.

UNITED
NATIONS

A

General Assembly

Distr.
LIMITED

A/AC.105/C.1/L.213/Add.2
26 February 1997

ORIGINAL: ENGLISH

COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE
Scientific and Technical Subcommittee
Thirty-fourth session
Vienna, 17-28 February 1997

DRAFT REPORT OF THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE ON THE WORK OF ITS THIRTY-FOURTH SESSION

E. Regional and interregional cooperation

1. The Subcommittee noted that the General Assembly, in its resolution 51/123, emphasized the importance of implementing fully the recommendations of UNISPACE 82 regarding the promotion of the establishment and strengthening of regional mechanisms of cooperation through the United Nations system. The Subcommittee noted with satisfaction that, in carrying out various activities in the implementation of the recommendations of UNISPACE 82, the Secretariat had sought to strengthen those mechanisms.

2. The Subcommittee noted with appreciation the efforts undertaken by the United Nations Programme on Space Applications, in accordance with General Assembly resolution 45/72, in leading an international effort to establish regional centres for space science and technology education in existing national or regional educational institutions in developing countries. The Subcommittee also noted that, once established, each centre could expand and become part of a network that could cover specific programme elements in established institutions related to space science and technology in each region.

3. The Subcommittee recalled that the General Assembly, in its resolution 50/27, had endorsed the recommendation of the Committee that the centres be established on the basis of affiliation to the United Nations as early as possible and that such affiliation would provide the centres with the necessary recognition and would strengthen the possibilities of attracting donors and of establishing academic relationships with national and international space-related institutions.

4. The Subcommittee recalled that the General Assembly, in its resolution 51/123, had noted with satisfaction that the regional Centre for Space Science and Technology Education in Asia and the Pacific had begun its first education programme in April 1996 and that significant progress had also been achieved in establishing regional centres for space science and technology education in the other regions covered by the regional commissions.

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5. The Subcommittee noted with regard to the regional Centre for Space Science and Technology Education in Asia and the Pacific, inaugurated in India in November 1995, that participation in the governing board of the Centre and in its activities was open to Member States in the region and that, in due course and upon approval by its governing board, the Centre would grow into a network of nodes enabling it to fully utilize the resources and potential of the region. The Subcommittee noted with satisfaction that the first nine-month education programme of the Centre had focused on remote sensing and the Geographic Information System (GIS) and had been completed and that the second programme on satellite communications had started in January 1997.

6. Some delegations expressed the view that the Office for Outer Space Affairs should undertake further consultations among States in the region in order to resolve the outstanding differences in respect of the Centre in Asia and the Pacific.

7. The Subcommittee noted with satisfaction that Brazil and Mexico had announced their intention to sign the agreement establishing the regional Centre for Space Science and Technology Education in Latin America and the Caribbean in March 1997. The Subcommittee also noted with satisfaction the statement of the delegation of Bolivia, on behalf of the Latin American and Caribbean States, supporting the future establishment and operation of that Centre for the benefit of the States in the region and expressing the profound interest of those States in participating in the activities of the Centre.

8. Regarding the centres in Africa, the Subcommittee noted that Morocco (for the French-speaking African countries) and Nigeria (for the English-speaking African countries) were developing cooperation agreements that would be entered into by the States concerned later in 1997.

9. The Subcommittee noted that discussions were in progress with Jordan, Saudi Arabia and the Syrian Arab Republic on the establishment of a regional centre in western Asia.

10. The Subcommittee noted that discussions between Bulgaria, Greece, Poland, Romania, Slovakia and Turkey were in progress on the establishment of a network of space science and technology education and research institutions for central eastern and south-eastern European countries and that the activities of the network would be in harmony with the relevant work of existing institutions in Europe and would be open to international cooperation. The Subcommittee noted that a meeting of experts had been held at Vienna from 17 to 18 October 1996 on the establishment of the network and that the experts had resumed their deliberations from 13 to 14 February 1997. The Subcommittee further noted that at the resumed session, the experts had agreed to work with the Office for Outer Space Affairs to undertake a study on the technical requirements, design, operation mechanism and funding of the Network.

11. The Subcommittee noted that the satellite-based COPINE project would offer an excellent opportunity for the exchange of information needed to promote progress in health care, agriculture, education, science and technology, and the management and survey of natural resources and the environment in Africa. The Subcommittee noted that such cooperation would provide long-term benefits to the participating African countries and would contribute to economic growth in the region.

12. The Subcommittee noted that the 4th Asia-Pacific Conference on Multilateral Cooperation in Space Technology and Applications would be hosted by the United Arab Emirates in December 1997 and that it would provide opportunities for technologists, experts and decision makers to discuss the framework and mechanisms to institutionalize regional cooperation in the development and applications of space technology.

13. The Subcommittee noted the announcement of the Latin American Seminar on Aerospace Medicine, to be held under the auspices of the United Nations at Santiago, Chile, from 5 to 6 June 1997, with the objective of disseminating the analyses of progress of human activities in space and promoting regional cooperation in that specialized discipline.

14. The Subcommittee took note of the proposal of Ukraine to host an International Congress on the theme "Philosophy of space activities at the threshold of a new millennium" at Kiev from 12 to 17 May 1998. Special attention would be paid to the questions of space activities and recent global problems of humankind; global information systems and space telecommunications technology; space science; and legal issues related to space activities.

15. The Subcommittee noted the contributions made by specialized agencies and other international organizations towards the promotion of international cooperation in space activities: FAO was continuing its activities relating to the remote sensing of renewable natural resources and environmental monitoring, including training courses and the support of development projects; the World Meteorological Organization (WMO) was continuing international cooperative programmes using space technology, including the World Weather Watch and the Tropical Cyclone Programme; the United Nations Educational, Scientific and Cultural Organization (UNESCO) was promoting applications of space technology for archaeology and strengthening international and interdisciplinary cooperation between archaeological projects; UNIDO was continuing its work on spin-off benefits of space technology; INTELSAT was further developing its system for international satellite communications and broadcasting, including its programmes for training and technical assistance; ESA was continuing its programme of international cooperative space activities, including training programmes for the benefit of developing countries, support of the activities of the United Nations Programme on Space Applications and technical assistance projects; and the International Civil Aviation Organization (ICAO) was continuing its work towards implementation of communications, navigation and surveillance/air traffic management (CNS/ATM) systems.

16. The Subcommittee emphasized the importance of regional and international cooperation in making the benefits of space technology available to all countries by such cooperative activities as sharing payloads, disseminating information on spin-off benefits, ensuring compatibility of space systems and providing access to launch capabilities at reasonable cost.

III. MATTERS RELATING TO REMOTE SENSING OF THE EARTH BY SATELLITES INCLUDING, *INTER ALIA*, APPLICATIONS FOR DEVELOPING COUNTRIES

17. In accordance with General Assembly resolution 51/123, paragraph 18 (a), the Subcommittee continued its consideration of the item relating to remote sensing of the Earth.

18. In the course of the debate, delegations reviewed national and cooperative programmes in remote sensing. Examples were given of national programmes in developing and developed countries and of international programmes based on bilateral, regional and international cooperation, including programmes of technical cooperation between developing countries. Delegations of countries with advanced capabilities in the field, including some developing countries, described programmes to provide assistance to developing countries.

19. The Subcommittee took note of the continuing programmes of Argentina, Australia, Austria, Brazil, Canada, China, Ecuador, France, Hungary, Germany, India, Indonesia, Japan, Lebanon, Morocco, Romania, Russian Federation, Ukraine, United States, as well as ESA, for the development and use of information generated from remote sensing satellites. The Subcommittee noted that the European Remote Sensing (ERS-2) satellite, the RADARSAT satellite of Canada, the ADEOS-1 satellite of Japan, and the IRS-P3 satellite of India were providing

valuable microwave data to complement the data from ERS-1 and from the Japanese Earth Resources Satellite (JERS-1), as well as the visible and infrared data from satellites of IRS-1C, Landsat, Resurs, SPOT, Indian Remote Sensing (IRS) and Marine Observation Satellite (MOS) series. The Subcommittee also noted the remote sensing systems being developed for future launch, including SAC-C of Argentina, Fengyan-2 and Ziyuan-1 of China, RADARSAT-II of Canada, CBERS of China and Brazil, Jason-1 of France, IRS-1D of India, ADEOS 2 and the Advanced Land Observing Satellite (ALOS) of Japan and the Tropical Rainfall Measuring Mission (TRMM) of Japan and the United States, and various systems of the Russian Federation. It also took note of the joint German-Russian long-term Modular Optoelectronic Multispectral Stereo-Scanner (MOMS) mission on MIR, the Applications Development Research Opportunity (ADRO) programme of NASA and the Canadian Space Agency, as well as the activities of France in the area of combating desertification using Satellite pour l'observation de la Terre (SPOT) data in cooperation with the countries concerned. It also took note of the activities of ISPRS in promoting international cooperation in remote sensing and image processing. The Subcommittee heard a scientific and technical presentation on the remote sensing activities of Morocco in the management of water resources, as described in paragraph __ of the present report.

20. The Subcommittee reiterated its view that remote sensing activities should take into account the need to provide appropriate and non-discriminatory assistance to meet the needs of developing countries.

21. The Subcommittee emphasized the importance of making remote sensing data and analysed information openly available to all countries at reasonable cost and in a timely manner. The Subcommittee also recognized the example of international cooperation in WMO in the exchange of meteorological data as provided for in resolution 11.4/1 adopted at the XIIth WMO Congress on 21 June 1995. Some delegations called attention to the international cooperation given by some members through traditionally free and open provisions of meteorological satellite data and encouraged those countries to continue that practice.

22. The Subcommittee considered that international cooperation in the use of remote sensing satellites should be encouraged, both through coordination of the operation of ground stations and through regular meetings between satellite operators and users. It noted the importance of compatibility and complementarity of existing and future remote sensing systems, as well as the need for continuity in the acquisition of data. The Subcommittee also noted the importance, particularly for developing countries, of sharing experiences and technologies, of cooperation through international and regional remote sensing centres and of joint work on collaborative projects. The Subcommittee further noted the value of remote sensing systems for environmental monitoring and, in that context, stressed the need for the international community to fully utilize remote sensing data in an effort to fully implement the recommendations contained in Agenda 21,[1] adopted by the United Nations Conference on Environment and Development, held at Rio de Janeiro from 3 to 14 June 1992.

23. The Subcommittee noted with satisfaction the prototype Information Locator Service (ILS), funded by DARA and currently in the design and implementation phase. The Subcommittee also noted that the system was being designed to assist users in developing countries in locating and accessing sources of information about Earth observation data, projects and services to meet their needs. It further noted that the system technology was based on a special World Wide Web server that would be installed at various strategic nodes and would be equipped with a feature to enable users in developing countries to include and maintain their own data and to design the content to suit their own specific needs.

24. The Subcommittee took note of the programmes of Argentina, Bulgaria, Mexico, Morocco, Pakistan, Romania and Spain in the area of small satellites and microsatellites. The Subcommittee recalled that at its thirty-third session, it had recommended that more of the activities of the United Nations Programme on Space Applications should be devoted to that theme (A/AC.105/637 and Corr.1, para. 182). Some delegations expressed the view that the subject of small satellites should be included in the agenda of the Subcommittee. Some also expressed the view that the subject should be included as a possible agenda item for the UNISPACE III Conference.

25. Recalling General Assembly resolution 41/65 by which the Assembly adopted the Principles Relating to Remote Sensing of the Earth from Outer Space, the Subcommittee recommended that at its thirty-fifth session it should continue its discussion on remote sensing activities conducted in accordance with the Principles during its consideration of the agenda item concerning remote sensing.

26. The Subcommittee recommended that the item should be retained on its agenda as a priority item for its thirty-fifth session.

IV. USE OF NUCLEAR POWER SOURCES IN OUTER SPACE

27. In accordance with General Assembly resolution 51/123, paragraph 18 (a), the Subcommittee continued its consideration, on a priority basis, of the item relating to the use of nuclear power sources in outer space.

28. The Subcommittee recalled that the General Assembly had adopted the Principles Relevant to the Use of Nuclear Power Sources in Outer Space, contained in its resolution 47/68. The Subcommittee noted that the Committee[2] at its thirty-ninth session, had recalled the agreement reached at its thirty-eighth session that the Principles should remain in their current form until amended and that, before amendment, proper consideration should be given to the aims and objectives of any proposed revision.[3] The Subcommittee agreed that, at the present time, revision of the Principles was not warranted. The Subcommittee also agreed that, until a firm scientific and technical consensus had been reached on the revision of the Principles, it would be inappropriate to pass the topic to the Legal Subcommittee.

29. The Scientific and Technical Subcommittee also recalled that it had agreed at previous sessions that regular discussions on that issue should continue at future sessions and that it should continue to receive the widest input on matters affecting the use of nuclear power sources in outer space and any contribution related to improving the scope and application of the Principles.

30. The Subcommittee noted the statement made by the representative of IAEA stating that the Principles should be reviewed in view of the most recent International Commission on Radiological Protection (ICRP) recommendations on radiation safety incorporated into the IAEA International Basic Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, published by IAEA as Safety Series No. 115. The IAEA noted in particular that the principles relating to notification of re-entry of space objects with nuclear power sources on board, as well as those relating to subsequent assistance to States, should be revised in view of the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. The Subcommittee noted that Safety Series Practice Document No. 119, entitled *"Emergency Planning and Preparedness for Re-entry of a Nuclear Powered Satellite"*, had been published by IAEA in its final form in 1996.

31. Mindful of the differences in the safety principles applied for space and the safety standards for terrestrial systems, the Subcommittee agreed that the study of those developments, arising from the latest ICRP recommendations, should be continued.

32. The Subcommittee agreed, at its 494th meeting, on 25 February 1997, to reconvene its Working Group on the Use of Nuclear Power Sources in Outer Space, under the chairmanship of D. Rex (Germany). The Working Group met from 25 to __ February 1997. At a meeting held on __ February 1997, the Working Group adopted its report.

33. At its __ meeting, on __ February 1997, the Subcommittee adopted the report of the Working Group, which is contained in annex III to the present report.

34. The Subcommittee noted that in response to its recommendation, the General Assembly, in resolution 51/123, paragraph 22, had invited Member States to report to the Secretary-General on a regular basis with regard to national and international research concerning the safety of space objects with nuclear power sources on board. The Subcommittee also noted that the General Assembly, in paragraph 32 of the same resolution, had considered that, to the extent possible, information on the problem of collisions of space objects, including those with nuclear power sources, with space debris should be provided to the Subcommittee, in order to allow it to follow that area more closely. The Subcommittee noted that information had been submitted in response to those requests by Brunei Darussalam, Bulgaria, Canada, Germany, Hungary, Japan, Portugal, Republic of Korea, Russian Federation, Sweden and United Kingdom (A/AC.105/659 and Add. 1 and 2).

35. The Subcommittee heard scientific and technical presentations on the topic of nuclear power sources by the Russian Federation, as described in paragraph __ of the present report.

36. The Subcommittee took note of the working paper submitted by the Russian Federation on the use of nuclear power sources in outer space (A/AC.105/C.1/L.208) and by the United Kingdom on progress with revision of the Principles (A/AC.105/C.1/L.210).

37. The Subcommittee agreed that Member States should continue to be invited to report to the Secretary-General on a regular basis with regard to national and international research concerning the safety of space objects with nuclear power sources. The Subcommittee also agreed that further studies should be conducted on the issue of the collision of orbiting space objects with nuclear power sources on board with space debris and that it should be kept informed of the results of such studies.

38. While agreeing that a revision of the Principles was not necessary at the present time, the Subcommittee stressed that it was important that States making use of nuclear power sources in space should conduct their activities in full accordance to the Principles.

39. Some delegations expressed the view that space objects with nuclear power sources on board could be used for limited purposes such as inter-planetary space missions where conventional solar power might not provide sufficient power. One delegation expressed the view that, since most accidents occurred in the ascending, descending and pre-orbital stages, it was important to follow the Principles and to continue in-depth studies on operational technology and safety norms. That delegation also expressed the view that the launch vehicles used for space objects with nuclear power sources on board should be designed to ensure successful launches and to avoid the destruction of the nuclear power source in the event of an accident through the reinforced structure and the design of the nuclear power source on board.

40. One delegation expressed the view that in developing future space objects equipped with nuclear power sources, measures to ensure safety (radiation, nuclear, ecological) would be aimed at minimizing the effects of ionizing emissions and radioactive and toxic materials on the population and the environment, including outer space. That delegation also expressed the view that the safety of those spacecraft at all stages of their operation and in the event of foreseeable accidents would be ensured by safety systems and nuclear power source structural elements designed to meet safety requirements and by special comprehensive administrative and technical measures to prevent accidents and eliminate the effects of accidents.

41. Some delegations expressed the view that in due time the Principles might be updated by supplementary principles. Some delegations also expressed the view that in considering possible revisions of the Principles, reference should be made to the IAEA Safety Series publication on emergency planning and preparedness for re-entry of a nuclear powered satellite.

42. Other delegations expressed the view that revising or supplementing the Principles was not necessary at the present time and that the Principles should remain in their current form until a solid technical foundation on the subject could be established.

43. The view was also expressed that, in the light of submissions made to the Subcommittee and its Working Group on the Use of Nuclear Power Sources in Outer Space, and particularly the inconsistencies identified by IAEA, work on preparing for the revision of the Principles should be initiated.

44. The Subcommittee recommended that the item be retained on its agenda for the thirty-fifth session and that the time allocated to the topic in the Subcommittee and the Working Group should be adjusted as appropriate.

V. SPACE DEBRIS

A. General matters

45. In accordance with General Assembly resolution 51/123, paragraph 18 (a), the Subcommittee continued its consideration, on a priority basis, of the agenda item on space debris.

46. The Subcommittee agreed that consideration of space debris was important and that international cooperation was needed to expand appropriate and affordable strategies to minimize the potential impact of space debris on future space missions.

47. The Subcommittee noted with appreciation the report by the Secretariat (A/AC.105/663) prepared in response to its request to compile on an annual basis the information on various steps taken by space agencies for reducing the growth or damage potential of space debris and to encourage common acceptance of those steps by the international community, on a voluntary basis (A/AC.105/605, para. 80).

48. The Subcommittee took note of the following programmes of Member States and organizations on the acquisition and understanding of data on the characteristics of the space debris environment and on measuring, modelling and mitigating the orbital debris environment. The Subcommittee noted the following modelling programmes: the fast analytical model CHAINEE and a new semi-deterministic modelling tool, the Long Term Utility for Collision Analysis (LUCA) of Germany; studies on space debris modelling in China, India, Italy and Japan; the Integrated Debris Evolution Suite (IDES) of the United Kingdom; the complex BUMPER, CHAIN, EVOLVE and ORDEM 96 models of the United States; analytical and numerical models developed by the Russian Federation; and the Space Debris Reference Model (MASTER) of ESA. The Subcommittee also noted the following measuring and mitigation programmes: the Material Exposure in Low Earth Orbit (MELEO) experiment and the Advanced Composite Material Exposure Experiment (ACOMEX) of Canada; the Tracking and Image Radar Station (TIRA) of Germany, the Long Duration Exposure Facility (LDEF), the Haystack Orbital Debris Radar, the Orbital Debris Radar Calibration Spheres (ODERACS-1 and 2), the Charged Couple Device (CCD) Debris Telescope and the Liquid Metal Mirror Telescope (LMMT) of the United States; the Space Flyer Unit (SFU), the Communication Research Laboratory (CRL) telescope system and Middle and Upper Atmosphere (MU) radar system of Japan; studies on space debris and practical mitigation techniques in China and France; and the various monitoring facilities established by the Russian Federation.

49. The Subcommittee took particular note of the reports on the first confirmed collision of two catalogued objects in orbit. The Subcommittee noted that the collision had occurred on 24 July 1996 and, although it was not directly observed, sufficient evidence had been obtained from the orbit and attitude behaviour of the two objects involved. The Subcommittee further noted that the event was significant for the validation of statistical models predicting the probability of similar collisions in the future.

50. The Subcommittee agreed that Member States should pay more attention to the problem of collisions of space objects, including those with nuclear power sources on board, with space debris and other aspects of space debris. It noted that the General Assembly, in its resolution 51/123, had called for the continuation of national research on that question, for the development of improved technology for the monitoring of space debris and for the compilation and dissemination of data on space debris. The Subcommittee recalled the request of the Assembly that information on those issues should be submitted to the Subcommittee, and took note of the replies from Member States (A/AC.105/659 and Add. 1 and 2) that had been submitted to it in accordance with that request. The Subcommittee further agreed that national research on space debris should continue and that Member States and international organizations should make available to all interested parties the results of that research, including information on practices adopted that had proved effective in minimizing the creation of space debris.

51. The Subcommittee heard scientific and technical presentations on the subject of space debris by France, Germany, Japan, United Kingdom, United States, ESA and IADC as mentioned in paragraph __ of the present report.

52. The Subcommittee noted that cooperation had continued through the Inter-Agency Orbital Debris Coordination Committee (IADC), with the participation of Japan, NASA, ESA, the Russian Space Agency , the Chinese National Space Agency and, since 1996, the British National Space Centre, the Centre national d'études Spaciales (CNES) and ISRO, to enable its members to exchange information on space debris activities facilitate opportunities for cooperation in space debris research, review the progress of ongoing activities and identify debris mitigation options. The Subcommittee also noted that the German Space Agency (DARA) had applied for membership in IADC in 1997.

53. The Subcommittee noted with satisfaction that, following its invitation, representatives of IADC had made a technical presentation on the subject of space debris modelling and risk assessment as mentioned in paragraph __ of the present report. The Subcommittee agreed that IADC should be invited to make a technical presentation on space debris mitigation practices at its thirty-fifth session.

54. The Subcommittee recalled that, in order to advance in its consideration of its agenda item on space debris, it had adopted, at its thirty-second session, a multi-year plan for consideration of space debris. The Subcommittee also recalled that at each session it should review the current operational debris mitigation practices and consider future mitigation methods with regard to cost-efficiency (A/AC.105/637 and Corr.1, para. 92).

55. The Subcommittee noted that at its thirty-third session, in accordance with the multi-year plan, it had focused its attention on measurements of space debris, understanding of data and effects of that environment on space systems, as reflected in its technical report for 1996 (A/AC.105/637 and Corr.1, paras. 94-138).

56. The Subcommittee took note of the technical changes and amendments to its technical report for 1996 (A/AC.105/C.1/L.214). Those changes would be incorporated in the full report of the Subcommittee on its multi-year work plan, which would be presented to the Subcommittee at its thirty-sixth session, in 1999.

57. At the current session, the Subcommittee focused its attention on modelling of the space debris environment and risk assessment.

B. Technical report of the Subcommittee for 1997

[Paragraphs to be added]

C. General views

58. The view was expressed that there was a need to develop a common database for space debris that could serve as a clearing house of information for the international community for research and further advancement of knowledge in that field.

59. Some delegations were of the view that adequate time should be allocated to the thirty-sixth session of the Scientific and Technical Subcommittee, in 1999, for the completion of the technical report on space debris.

60. Some delegations were of the view that the Legal Subcommittee should be informed of the discussions in the Scientific and Technical Subcommittee under the agenda item on space debris. The view was expressed that a "launcher pays" principle, similar to the "polluter pays" principle in global environmental issues, should be adopted as one of the fundamental elements of a legal regime aimed at reducing space debris and that, when such a principle would be adopted and applied, the launcher should pay a fee that could be used for joint research activities to reduce space debris.

61. Other delegations expressed the view that it would not be appropriate to discuss the issue of space debris in the Legal Subcommittee or to develop recommendations in the Scientific and Technical Subcommittee to underpin new legal norms for orbital debris in view of the many technical issues that still needed to be discussed by the Scientific and Technical Subcommittee in order to establish an adequate base of knowledge on the topic.

62. The view was expressed that, in the technical report on space debris, section 3.1.3, entitled "De-orbiting and re-orbiting of space objects", could be renamed "De-orbiting and re-orbiting of manoeuvrable space objects" and that a new section 3.1.4 could be inserted, entitled, "De-orbiting and re-orbiting of space objects without manoeuvring capability". In the view of that delegation, the Subcommittee could encourage the scientific community by manifesting its interest in the above problem through calls for more national research on non-manoeuvrable debris.

63. The view was expressed that the Subcommittee should establish a working group to discuss space debris and that it was important for the Subcommittee to have a common understanding of the term "space debris". The view was also expressed that the definition proposed at the thirty-second session of the Subcommittee (A/AC.105/605, para. 95) could be modified to include the words "whether their owners can be identified or not" after the words "including their fragments and parts" so that the definition would read as follows: "space debris are all man-made objects, including their fragments and parts, whether their owners can be identified or not, in Earth orbit or re-entering the dense layers of the atmosphere that are non-functional with no reasonable expectation of their being able to assume or resume their intended functions or any other functions for which they are or can be authorized". The view was expressed that further specification in the definition of space debris would deserve expert consideration at the thirty-fifth session of the Subcommittee.

64. The Subcommittee recommended that the item be retained on its agenda as a priority item for its next session.

Notes

1. *Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992* (United Nations publication, Sales No. E.93.I.8 and corrigenda), vol. I: *Resolutions Adopted by the Conference*, resolution 1, annex II.

2. *Official Records of the General Assembly, Fifty-first Session, Supplement No. 20* (A/51/20), para. 75.

3. Ibid., *Fifteenth Session, Supplement No. 20* (A/50/20), para. 62.

UNITED
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General Assembly

Distr.
LIMITED

A/AC.105/C.1/L.213/Add.3
26 February 1997

ORIGINAL: ENGLISH

COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE
Scientific and Technical Subcommittee
Thirty-fourth session
Vienna, 17-28 February 1997

DRAFT REPORT OF THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE ON THE WORK OF ITS THIRTY-FOURTH SESSION

XII. OTHER MATTERS

A. Preparations of the Advisory Committee for the Special Session of the Committee on the Peaceful Uses of Outer Space (UNISPACE III Conference)

1. The Advisory Committee noted that the General Assembly, in its resolution 51/123, paragraph 28, had endorsed the recommendation of the Committee on the Peaceful Uses of Outer Space that a special session of the Committee (UNISPACE III), open to all States Members of the United Nations, should be convened at the United Nations Office at Vienna, preferably in 1999, unless progress towards agreeing on an agenda in the Scientific and Technical Subcommittee at its thirty-fourth session makes it more appropriate to consider the year 2000.

2. The Advisory Committee also noted that in paragraph 29 of the same resolution, the General Assembly had requested the Committee on the Peaceful Uses of Outer Space and the Scientific and Technical Subcommittee to act as the Preparatory Committee and the Advisory Committee for the UNISPACE III Conference, to carry out the tasks entrusted to them in paragraphs 178 to 185 of the report of the Committee[1] and to report to the General Assembly at its fifty-second session on the progress made in the preparatory work for the UNISPACE III Conference.

3. The Advisory Committee decided that the Working Group of the Whole could be called upon to carry out the tasks entrusted to by the General Assembly and requested the Working Group of the Whole to give full consideration to those tasks and to report thereon to the Subcommittee.

4. At its __ meeting on __ February 1997, the Subcommittee adopted the report of the Working Group of the Whole, contained in annex II to the present report, and noted that the report of the Working Group provided the basis for the Committee on the Peaceful Uses of Outer Space, in its role as the Preparatory Committee for the UNISPACE III Conference, to carry out the task entrusted to it by the General Assembly.

5. Considering that the conference service resources available for the Committee and its subsidiary bodies would be utilized for the UNISPACE III Conference, the Subcommittee recommended that the duration of the meetings of the Committee and its subsidiary bodies in 1999 should not exceed a total of 16 days. The Advisory Committee further recommended that an indicative schedule of meetings for 1999 would be: 8 days for the Scientific and Technical Subcommittee and 5 days for the Legal Subcommittee, to be scheduled successively during February/March; and no more than 3 days for the Committee to be scheduled immediately prior to the UNISPACE III Conference in order to adopt the reports of the two Subcommittees and to complete the preparatory work for the conference unless it is considered more appropriate to hold it earlier. The exact schedule would be confirmed by the Committee in 1998 depending on the progress still to be made in the preparation for the UNISPACE III Conference and the agreement to be reached at the next session of the Scientific and Technical Subcommittee as to which of its agenda items should be considered at its 1999 session.

6. The Advisory Committee would encourage the participation of developing countries and assistance to least developed countries in order to work actively towards the attainment of the objectives and goals of the UNISPACE III Conference.

7. The Advisory Committee noted with satisfaction the offers made by COSPAR, IAF and ISPRS to participate in the UNISPACE III Conference and its preparatory activities by organizing symposia, colloquiums, training courses and workshops and by preparing documents to support the activities of the UNISPACE III Conference.

8. The Advisory Committee welcomed the contribution of the Third Space Conference of the Americas, held at Punta del Este, Uruguay, in November 1996, towards the achievement of the objectives of the UNISPACE III Conference.

9. The Advisory Committee recommended that the secretariat should inform the organizations within the United Nations system and other intergovernmental and non-governmental organizations with space activities on the date of the UNISPACE III Conference in order to avoid having other major space-related meetings scheduled during the time of the UNISPACE III Conference.

Notes

1. *Official Records of the General Assembly, Fifty-first Session, Supplement No. 20* (A/51/20).

UNITED
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General Assembly

Distr.
LIMITED

A/AC.105/C.1/L.213/Add.4
26 February 1997

ORIGINAL: ENGLISH

COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE
Scientific and Technical Subcommittee
Thirty-fourth session
Vienna, 17-28 February 1997

DRAFT REPORT OF THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE ON THE WORK OF ITS THIRTY-FOURTH SESSION

B. Technical report of the Subcommittee for 1997

1. Concerned about the influence of space debris on the space environment and on the operation of spacecraft, the Committee on the Peaceful Uses of Outer Space had included the item on space debris on its agenda in 1994. It was agreed that it was important to have a firm scientific and technical basis for future action on the complex attributes of space debris.

2. The Subcommittee agreed to focus on understanding aspects of research related to space debris, including debris measurement techniques; mathematical modelling of the debris environment; characterizing the space debris environment; and measures to mitigate the risks of space debris, including spacecraft design measures to protect against space debris. Accordingly, a multi-year work plan was adopted in 1995 for specific topics to be covered during the time-span 1996-1998. It was also agreed that that work plan should be implemented with flexibility, so that all relevant issues on space debris could be addressed.

3. The report of the Subcommittee would be structured according to the specific topics addressed by the work plan during the period 1996-1998. The report would be carried forward and updated each year, leading to an accumulation of advice and guidance, in order to establish a common understanding that could serve as the basis for further deliberations of the Committee on that important matter. The report for 1997 concentrates on the modelling of the space debris environment and risk assessment.

2. Modelling of the space debris environment and risk assessment

2.1 Modelling of the space debris environment

2.1.1 Introduction and methodology

4. Space debris models provide a mathematical description of the distribution of objects in space, the movement and flux of objects and the physical characteristics of objects (e.g. size, mass, density, reflection properties, intrinsic motion). These models can be deterministic in nature (i.e. each object is described individually by its orbital parameters and physical characteristics), statistical in type (i.e. characterization of an ensemble by a sample number of objects) or a combination (i.e. hybrid). These models can be applied to risk and damage assessments, prediction of debris detection rates for ground-based sensors, prediction of avoidance manoeuvres of operational spacecraft and long-term analysis of the effectiveness of debris mitigation measures.

5. Space debris models must consider the contribution to the population of orbiting objects of the following source mechanisms:

(a) Launches (including launch vehicle upper stages, payloads and mission-related objects);

(b) Manoeuvres (to account for solid rocket motor firings);

(c) Breakups (produced by explosions and collisions);

(d) Material separation from surfaces (ageing effects, e.g. paint flakes);

(e) Material due to leakage (e.g. nuclear power source (NPS) coolant).

6. The following sink mechanisms must also be considered:

(a) Orbital decay due to atmospheric drag or other perturbations;

(b) Retrievals from orbit;

(c) Deorbiting.

A debris environment model must contain all or some of these elements.

7. Space debris models make use of all available data sources. These include:

(a) Deterministic data on decimetre-size and larger objects within the United States Space Command Satellite Catalogue and the Russian Space Surveillance Catalogue;

(b) Statistical data on centimetre-size objects derived from dedicated radar campaigns in low-Earth orbit (LEO);

(c) Statistical data on encountered submillimetre debris populations inferred from analysis of retrieved surfaces;

(d) Ground-based simulations of hypervelocity collisions with satellite and rocket bodies;

(e) Ground-based simulations of explosive fragmentations.

8. These models are limited by the sparse amount of data available to validate the derived relationships. The models must rely upon historical records of satellite characteristics, launch activity and in-orbit breakups; in addition there is only limited data on spacecraft material response to impact and exposure to the orbital environment. Further, major assumptions must be made in applying these models to predict the future environment. In particular, future traffic scenarios and the application of mitigation measures will have a major influence on the outcome of the model predictions. Space debris models must be continually updated and validated to reflect improvements in the detail and size of observational and experimental data sets.

9. Environment models may take two forms: as discrete models, which represent the debris population in a detailed format, or as an engineering approximation, in the form of distribution functions. Furthermore, these models can be short term in nature (considering time-frames of up to 10 years) or long term (considering time-frames of over 10 years). In the preparation of all these models, the initial debris population is represented at a particular starting epoch and this is propagated forward in time in a stepwise manner taking account of source and sink mechanisms and relevant orbit perturbations.

10. The pertinent characteristics of the models are compared in table ... below.

2.1.2 Short-term models

11. The following short-term models are available in the scientific and engineering community:

(a) EVOLVE was developed by the NASA Johnson Space Centre to provide short- and medium-term forecasts of the LEO environment with extensive source terms and detailed traffic models, based on quasi-deterministic population propagation techniques;

(b) ORDEM96 is a semi-empirical engineering model developed by NASA Johnson Space Centre. It is based upon extensive remote and *in situ* observations and is used to support United States Space Shuttle and International Space Station design and operations;

(c) MASTER is an ESA semi-deterministic environment model based on 3D discretization of spatial densities and transient velocities. The model is applicable to altitudes from LEO to GEO providing environment estimates in the short term. A less detailed version of MASTER is available in an engineering format. Both models were developed by the Technical University of Braunschweig in Germany.

(d) IDES is a semi-deterministic model of the environment relying upon detailed traffic and satellite characteristics models to provide and short- and long-term predictions of the orbital debris environment. The model was developed by DERA Farnborough;

(e) Nazarenko, a model developed by CPS is a semi-analytic, stochastic model for the medium- and long-term prediction of the LEO debris environment, providing spatial density and velocity distributions. The model is based on Russian and United States catalogue data.

Model name	Source	Evolutionary period	Engineering model available	Minimum size	Orbital regime
CHAIN	NASA	Long term	No	1 cm	LEO
CHAINEE	ESA	Long term	No	1 cm	LEO
EVOLVE	NASA	Short + long term	No	0.01 mm	LEO
IDES	DERA	Short + long term	No	0.01 mm	LEO
LUCA	TUBS	Long term	No	1 mm	LEO/MEO
MASTER	ESA	Short term	Yes	0.1 mm	LEO/GEO
Nazarenko	RSA	Short term	No	0.6 mm	LEO
ORDEM96	NASA	Short term	Yes	0.01 mm	LEO
SDM/STAT	ESA	Long term	No		LEO/GEO

2.1.3 Long-term models

12. The scope of the long-term modelling of the orbital debris environment is the long-term (up to 100 years) prediction of the number of objects as a function of time, of altitude and of object size. These projections are important for assessing the necessity and the effectiveness of debris mitigation techniques.

13. In addition to the sources of space debris that are considered in the modelling of the current debris population, it is required to take into account collisions among larger objects (> 10 cm). Currently, collisions among larger objects do not play a significant role in the increase of the number of objects, since their probabilities are low. However, in the future, the interactive risk for so-called destructive collisions, i.e. collisions that generate larger fragments, may increase. This so-called interactive collision risk among all objects of the population is proportional to the square of the number of objects. Hence, if in the future the number of objects will increase as in the past (some per cent per year linearly), the interactive collision risk will increase.

14. In order to assess the consequences of collisions among larger objects it is necessary to have reliable break-up models for collisions of this type. However, it is very difficult to simulate on orbit collisions without having test data for validation purposes available. Hence, a certain degree of uncertainty is introduced into the models by the collision simulation.

15. Other than the modelling of the present debris population, the long-term modelling needs some assumptions describing the future space flight activities including the debris generation mechanisms in terms of, for example:

(a) Future number of launches and related orbits;

(b) Future number and size of payloads per launch;

(c) Future number of mission related objects (fairing, bolts etc.);

(d) Future number of explosions of spacecraft and upper stages.

16. All these parameters are subject to variations with time due to technical/scientific, financial and political aspects. Hence, some uncertainties are added to those uncertainties that are due to the mathematical model itself (break-up models etc.).

17. A number of models have been developed for the purpose of long-term modelling of the debris environment. They can be characterized briefly as follows:

(a) CHAIN, CHAINEE: CHAIN was developed by the Technical University of Braunschweig under government contract. Since 1993 this model has been maintained and improved by NASA. CHAINEE, the European extension of CHAIN, is used by ESA. The model, an analytical "particle-an-a-box" model, describes the population and the collision fragments of up to an altitude of 2,000 km using 4 altitude bins in LEO and 5 mass classes. CHAINEE is an extremely fast computer code (approximately 10 seconds for a 100-year simulation). It enables the identification of relative trends associated with specific mitigation policies. The resolution of CHAIN is limited due to the binning used;

(b) EVOLVE: The EVOLVE model has been developed by NASA. It is a semi-deterministic model, i.e. debris objects are described individually by a set of parameters. In addition to being capable of modelling the present debris environment, it can be used to investigate future evolutionary characteristics under various mitigation practices by the use of Monte Carlo techniques. For this purpose mission model data are used. The reliability and resolution of the model in terms of orbital altitude and object size are good due to its methodology;

(c) IDES: IDES was developed at the Space Department of DERA, at Farnborough, United Kingdom. The historical data are simulated until 1996. For the analysis of future scenarios, traffic models are used and the environment is evolved forward in time to account for interactions within the satellite population;

(d) LUCA: For the detailed analysis of future scenarios, especially if a high resolution concerning the orbital altitude and the declination is required, the semi-deterministic computer code LUCA has been developed at the Technical University of Braunschweig. This code combines the advantages of a high spatial resolution and of a tolerable computer time need. In order to calculate the time-dependent collision risk, a special tool has been implemented. This tool reflects the increased collision risks at higher declinations (e.g. close to the polar regions);

(e) STAT/SDM: At the University of Pisa, in Italy, two programs for the purpose of long-term modelling have been developed under an ESA contract. The stochastic approach (STAT) and the semi-deterministic model (SDM) use the same initial population and the same source and sink assumptions. In SDM, orbits of a representative subset of the population are used to calculate collision rates and to map the population forward in time. Spatial densities are stored in time-dependent altitude and mass bins. By means of parametric studies, effects of launch policies and mitigation measures on the population development can be analysed. STAT is a computer time efficient "particle-in-a-box" alternative to SDM. It is based on a system of coupled, non-linear differential equations that are numerically integrated.

18. The major findings of the above-mentioned long-term debris models can be summarized as follows:

(a) The debris population may grow uncontrolled in the future if space flight is performed as in the past. This is because of the increasing number of collisions that will occur among larger objects;

(b) Currently, fragments from explosions are the main source of space debris. Beyond a certain point in time, collision fragments may dominate the population;

(c) Should the second stage of this evolution occur, the so-called collisional cascading effect will set in. This means that collisional fragments will contribute to the number of subsequent collisions. At that point in time the population will grow exponentially.

19. The results of the long-term debris models do not agree completely. However, the basic trends and tendencies obtained by the models agree.

20. The collision probabilities among the larger objects are initially low. Hence, it is essential to analyse a number of single Monte Carlo runs or to use mean value approaches in order to obtain reliable trends and tendencies. The above models take care of that effect.

2.2 Orbital debris risk assessments

2.2.1 Introduction

21. Risk assessments include the probability of an event, as well as its subsequent consequences. With the assistance of models of the orbital debris environment, the risk of collision among operational spacecraft and orbital debris can be evaluated. Spacecraft in LEO are routinely bombarded by very small particles (<100 microns) because of the large number of such debris, but the effects are normally slight due to the small masses and energies involved. Because of the smaller population of large debris objects, the likelihood of collision decreases rapidly as the size of the debris increases. However, the severity of collisions between large objects increases.

22. The principal risk factors are the spatial density and average relative collisional velocity along the orbit (altitude and inclination) of the space object of interest, the cross-sectional area of the space object and the duration of the flight. The consequences of a collision will depend upon the respective masses and compositions of the objects involved. Whereas the collision risk between an orbiting object and a meteoroid is essentially independent of altitude, the probability of collision between orbital objects is strongly related to altitude, in general being an order of magnitude higher in LEO than in GEO.

2.2.2 Collision risk assessments in LEO

2.2.2.1 Methodology

23. Risk assessments have been routinely performed on LEO spacecraft since the 1960s. The Poisson model is used in cases where there is a large number of independent events and each event has a small probability of occurring. Man-made debris and micro-meteoroids meet these criteria for independence except in cases of a recent break-up or a meteor storm.

24. To compute the probability of an impact from space debris requires a meteoroid/orbital debris (M/OD) environment model, a spacecraft configuration and a mission profile. To compute the probability of a penetration and/or a failure due to space debris requires detailed knowledge of the spacecraft configuration, including:

(a) The geometry of critical subsystems;

(b) The penetration resistance or ballistic limit equation of each subsystem;

(c) Data on the ability of each subsystem to tolerate damage.

25. Based on this information, computer codes can calculate:

(a) The probability of space debris impacts for a given size particle;

(b) The probability of impact damage to any given subsystem;

(c) The probability of damage as a function of its location;

(d) The split between damage from man-made debris and micro-meteoroids.

2.2.2.2 Results of risk assessments.

26. Risk assessments in LEO are routinely utilized to enhance the safety of space operation. In cases involving human space flight risk assessments have proved invaluable in ensuring the safety of shuttle operations. Shuttle missions are operationally reconfigured whenever a pre-flight risk assessment indicates the risks of space debris are at an unacceptable level.

27. Risk assessments are being utilized to design the location and type of space debris shielding that will protect the crew as well as the crucial subsystems on the International Space Station.

28. Risk assessments are also utilized in the design of unmanned spacecraft. They aid in the placement of shielding to protect critical subsystems, as well as in the system design of large communication satellite constellations.

Table __. Meantime between impacts on satellites with cross-section area of 100 square metres

Orbital height	Objects 0.1-1.0 cm	Objects 1 ≥ 10 cm	Objects > 10 cm
500 km	1-10 years	350-700 years	15,000 years
1,000 km	0.3-3 years	70-140 years	2,000 years
1,500 km	0.7-7 years	100-200 years	3,000 years

2.2.3 Collision risk assessments in GEO

29. Currently, the population of space objects in and near the GEO regime is known well for only spacecraft and upper stages. The limited number of these objects, their wide spatial distribution and the lower average relative velocities (500 m/sec) combine to produce a substantially lower probability of collision in GEO. Moreover, as more spacecraft and upper stages are left in orbits above or below GEO, the number of uncontrolled intact objects intersecting the GEO regime is increasing at a very slow rate. Special collision possibilities exist in GEO because of the close proximity of operational spacecraft at selected longitudes, but these collision hazards can be eliminated by spacecraft control procedures. The limited number of large objects near GEO also permits the prediction of close approaches between operational spacecraft and orbital debris in sufficient time to conduct an evasive manoeuvre.

30. The number of orbital debris of less than 1 metre in diameter near GEO is not well known. Two break-up—one a spacecraft and one an upper stage—have been identified, and some evidence suggests that additional break-ups may have occurred. Such debris, however, would be perturbed into inclined orbits, reducing the residence time in GEO but also increasing the relative collision velocity. In many cases debris fragments would be sidely dispersed in both altitude and inclination. Additional orbital debris measurements in GEO are needed before more accurate risk assessments can be performed. Also, new probability of collision techniques may need to be developed to take into account the non-random nature of close approaches in GEO.

31. There is no natural removal mechanism for satellites in GEO. Therefore operational spacecraft are at risk to be damaged by uncontrolled spacecraft. This annual collision risk for an operational satellite is currently estimated at 10^{-5}.

2.2.4 Risk assessments for re-entering orbital debris

32. The risk assessment discussed here is limited to the uncontrolled re-entry from Earth orbit.

33. There have been more than 16,000 known re-entries of catalogued space objects in almost 40 years. No significant damage or injury has been reported. In large measure this can be attributed to the large expanse of ocean surface and the sparse population density in many land regions. In the past five years, approximately once each week, an object with a cross-section of 1 square metre or more has re-entered Earth's atmosphere and some fragments have been known to survive.

34. The risk of re-entry is not only from mechanical impact, but also from chemical or radiological contamination to the environment. Mechanical damage will be caused by objects surviving aerodynamic heating. This risk will depend on the characteristics of the final orbit, the shape of the object and its material properties.

35. An assessment of re-entry risk must include the shape of the object and analysis of the altitude of the aerodynamic destruction, identification of components that can survive re-entry, the modelling of these components and the calculation of total casualty area.

36. There is no international consensus on human casualties caused by re-entry. A casualty expectation of 10^{-4} is presented in NASA safety standard 1740.14, entitled "Guidelines and assessment procedures for limiting orbital debris".

37. The Subcommittee noted that at its thirty-fifth session, it should focus on the last item of its multi-year work plan, space debris mitigation measures. It agreed that it would be desirable to invite the International Academy of Astronautics, through its Subcommittee on Space Debris, to prepare a comprehensive working paper on the mitigation practices currently in use, as well as on proposed measures of space debris mitigation.

38. The following section is to be completed at the thirty-fifth session of the Scientific and Technical Subcommittee:

3. Space debris mitigation measures

3.1 Reduction of the debris increase in time

3.1.1 Avoidance of mission-related objects

3.1.2 Improved structural integrity of space objects (explosion prevention etc.)

3.1.3 De-orbiting and reorbiting of space objects

3.2 Protection strategies

3.2.1 Shielding

3.2.2 Collision avoidance

3.3 Effectiveness of mitigation measures

4. Figures

39. Figures I-VIII, presented below, are preliminary versions and will be incorporated into the final technical report on space debris of the Subcommittee.

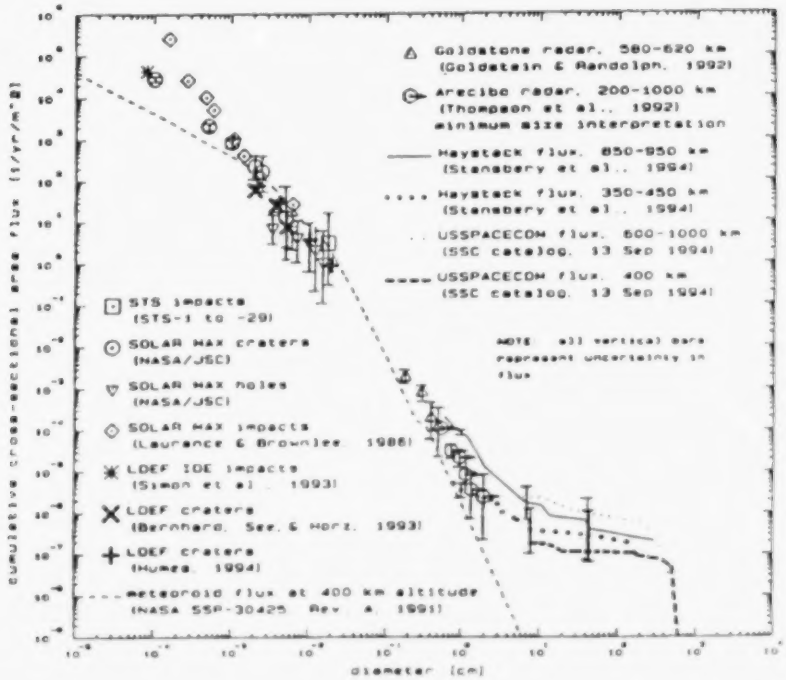

Figure I. Approximate measured debris flux in low-Earth orbit, by object size

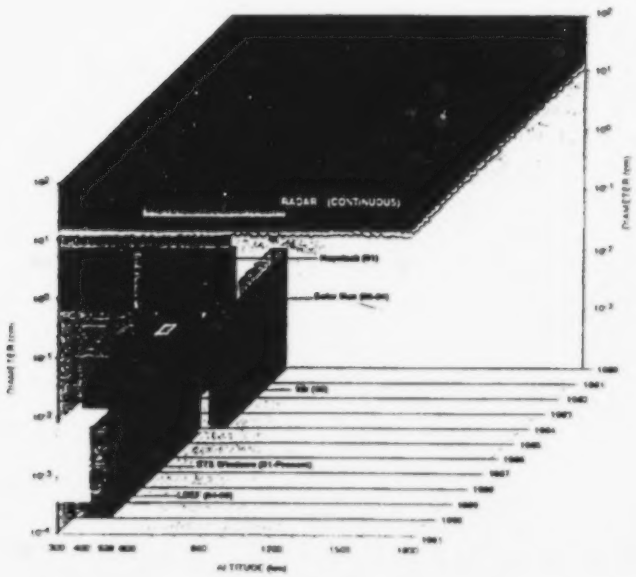

Figure II. Orbital debris characterization data: diameter versus altitude versus year

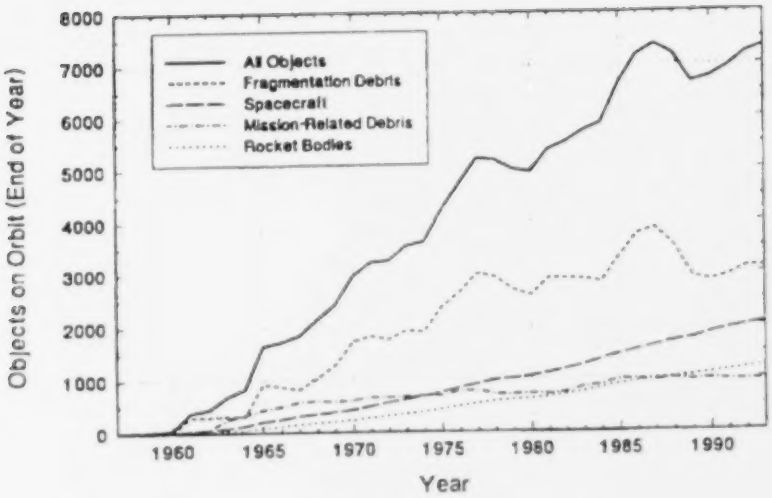

Figure III. On-orbit catalogued population, corrected for delayed cataloguing

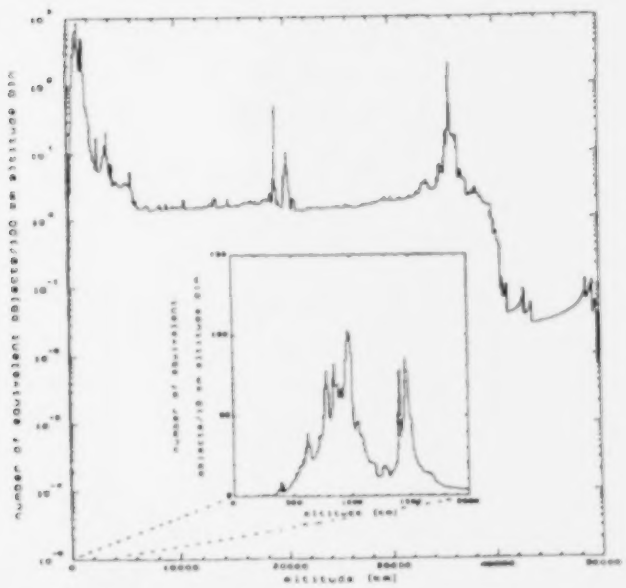

Figure IV. Distribution of satellites in Earth orbit

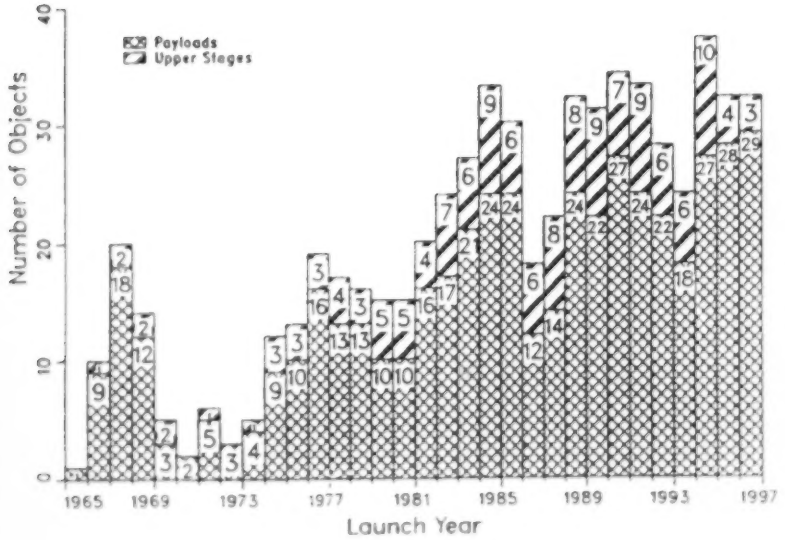

Figure V. Payloads and upper stages launched into geostationary orbit

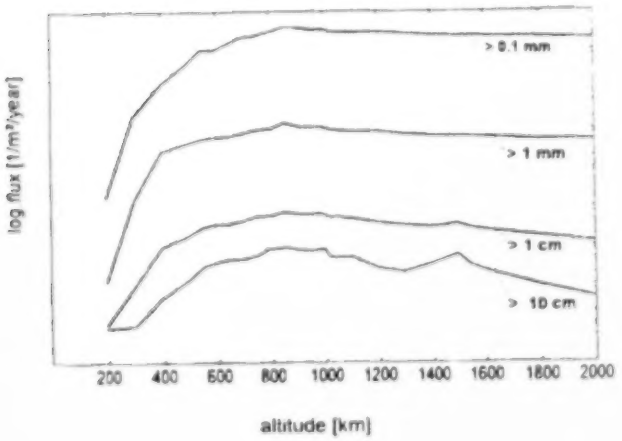

Figure VI. The object flux in low-Earth orbit

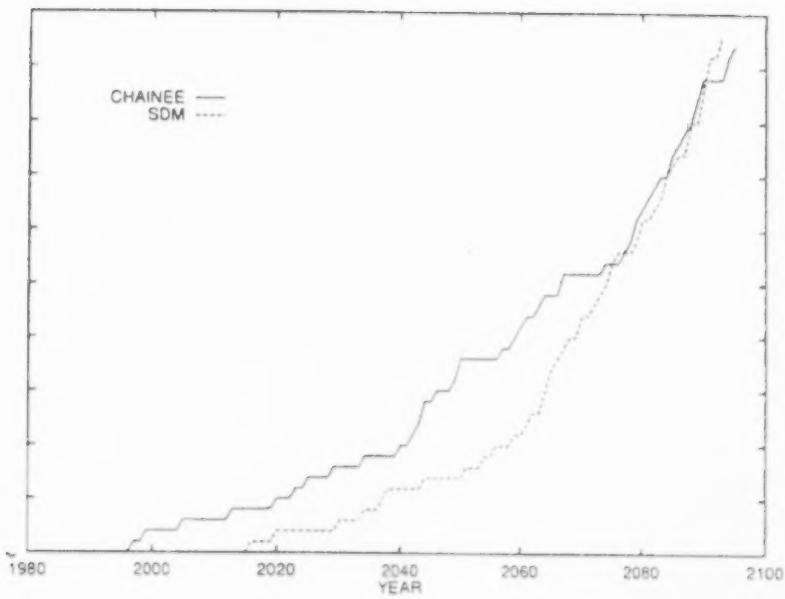

Figure VII. Cumulative number of destructive collisions

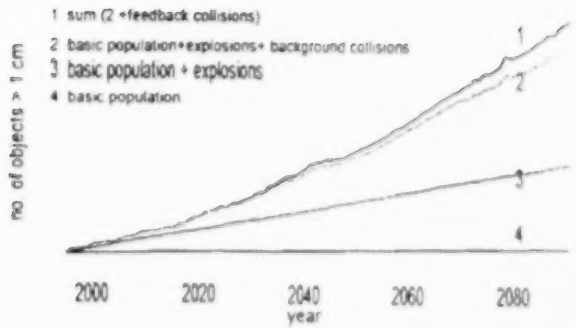

Figure VIII. Simulated population assuming business as usual